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THE CONTRIBUTIONS OF PASTEUR TO MEDICINE AND HUMANITY[1]

IN his éloge of Littré, Pasteur, speaking of the Greeks, says these words: "Ce sont eux qui nous ont legué un des plus beaux mots de notre langue, le mot enthousiasme—un Dieu intérieur. La grandeur des actions humaines se mesure à l'inspiration qui les a fait naître. Heureux celui qui porte en soi un dieu. . . ."[2]

Enthusiasm—a God within! Happy indeed is he who bears this "God within"! The son of a tanner, a non-commissioned officer of the Armies of Napoleon, Pasteur was born at Dôle in the Franche Compté on 27 December, 1822. His first studies were at the Collège d'Arbois, whither his parents moved while he was yet a baby. In 1839, he entered the Lycée of Besançon, where he received his Baccalaureat ès arts. In 1842, he became Bachelier ès sciences. In the same year he entered the École normale supérieur, fifteenth out of a class of twenty-two. Dissatisfied with this rank he resigned and went to Paris to an institution directed by a compatriot in the impasse des Feuillantines. There he followed courses at the Lycée St. Louis and listened to the lectures of Dumas at the Sorbonne. At the end of the year, he was admitted fourth in rank to the École normale. Not remarkable as a student, he was classed seventh in his examinations for license, and third out of four candidates who were received at the Concours d'agrégation; and when he presented himself for his Doctorat, his two theses received but mediocre appreciation.

But this modest student bore a "God within" which led him on his way. That pathway was singularly straight and direct, for, as has been pointed out by many, the logical sequence throughout all Pasteur's work is striking and remarkable.

Beginning as a chemist he was led fatally into questions of general biology and thence to questions of pathology and therapy, animal and human. To the careless eye the way might seem winding and beset

[1] Address delivered at the Sorbonne on May 22, 1923, on the occasion of a meeting organized by the American Committee for the Commemoration of the Pasteur Centenary.

[2] "They have given us one of the most beautiful words of our language, the word enthusiasm—a God within. The grandeur of the acts of men is measured by the inspiration from which they spring. Happy is he who bears a God within!"

by digressions, but from the patient labors of his early days to the triumphs of his maturity each observation led so naturally to the other—from his earliest studies in crystallography to his work on rabies—that the story of Pasteur's contributions to humanity and medicine is the story of his scientific life.

EARLY STUDIES IN CRYSTALLOGRAPHY

In the course of his studies between 1848 and 1853, while repeating certain measurements of crystals of tartaric and paratartaric acid and their salts which had been made by Provostaye, he observed that the crystals of the tartrates bore hemihedral facets like those of quartz; the crystals were dissymmetrical, the facets occurring only on the right side; solutions rotated polarized light to the right. Crystals of the paratartrates, on the other hand, although chemically identical, bore like facets *symmetrically arranged on both sides; their solutions were optically inactive.* This led Pasteur to fancy that a relation might exist between the asymmetry of the crystals and the optical activity of their solutions—a relation like that between the asymmetrical crystals of quartz and the optical activity of blocks cut from them.

Struck by a statement of Mitscherlich that one of the salts of paratartaric acid gave rise to asymmetrical crystals similar to those of the corresponding tartrates, Pasteur discovered that, in reality, when this salt was crystallized it resolved itself into two groups of dissimilar, asymmetrical crystals of tartaric acid, which were reciprocally symmetrical; that is, each was as the image of the other in a mirror. The one group bore hemihedral facets on the right, the other, which was new to science, on the left. Solutions of the one deviated polarized light to the right, of the other, to the left.

The rotatory power residing in solutions of these crystals, Pasteur ascribed to like dissymmetry in the atomic structure of the molecules.

In this fruitful hypothesis as to molecular structure lay *the germ of the theory of stereo-chemistry.*

More than this, Pasteur observed that in fermentation of solutions of paratartaric acid, associated with the growth of a common mould (*Penicilium glaucum*) the organism, in its development, consumed the dextro-rotatory component of the salt, thus changing an optically inert solution of paratartrates to a laevo-rotatory solution of tartrates.

Considering, in connection with these studies, the optically active character of the principal constituents of living bodies, such as the albumens, the celluloses and the sugars, Pasteur conceived the importance of molecular dissymmetry in the phenomenon of life.

In these initial studies Pasteur one day broke a piece from an octahedral crystal and dropped the injured crystal again into its mother liquid. With the renewed growth of the crystal a special activity was evident at the injured spot; in several hours the crystal had assumed its original form. And Pasteur, whose active mind always cast about for the ultimate significance of his observations and discoveries, called attention to the circumstance that the cicatrization and repair of wounds might well be compared with this physical process.

In 1849 Pasteur was made professor of physics in the University of Strasbourg. There in the same year, he married Marie Laurent, daughter of the rector of the university—a noble woman who throughout his life was his patient and devoted companion and helpmate, his assistant, his adviser, his inspiration.

FERMENTATIONS

Later, in 1854, when professor and dean of the faculty of sciences in Lille, the father of one of his pupils laid before him certain difficulties in the making of alcohol from beets and Pasteur began the study of fermentations. Here from the beginning it was his earlier experiences that guided him on the way.

The growth of yeasts in association with fermentation had been known and discussed from the days of Leeuwenhoeck in 1689, but despite the observations of Schwann and Cagriard-Latour, purely chemical and physical explanations still reigned. Fermentation, according to the prevailing ideas of the day (Liebig), depended on the breaking down of the molecule by decay and disintegration, set in motion by the presence of some dead nitrogenous material. Pasteur's observations had shown him that, excepting in the presence of a living substance, molecular dissymmetry, which renders a body optically active, disappears with the breaking up of the original molecule. On the basis of his experience he was convinced that a dissymmetrical disposition of the elementary atoms of the molecule on which optical activity depended, could be created only through the intervention of some vital process. That vital process was the growth of a yeast.

In the fermentation of potato amyl alcohol is produced which is laevo-rotatory; but the molecular constitution of the amyl alcohol is too far removed from that of the sugar from which it is derived to retain the molecular dissymmetry and the optical activity of the sugar molecule. In the creation of such a substance some vital process must have intervened. The question of lactic acid fermentation was especially intriguing to Pasteur because Liebig had asserted that here no yeast was present. But Pasteur showed clearly that this fermentation was dependent upon a living organism, a bacillus, so small that its presence

had escaped the notice of others. The organism was the ferment. At first he called it a yeast, so unimportant to him was its form. As Delezenne has said, "It is not in form, it is above all in functional aptitudes that Pasteur found the proof of the specificity of micro-organisms. For the first time morphology made way for physiology in the definition of species."[3] He showed that the ferment reproduced itself, and at the very beginning he asserted: "The purity of a ferment, its homogeneity, its free development without interference, with the aid of a nutrient medium adapted to its individual character, this is one of the essential conditions for good fermentations." And again: "If, in the saccharine, albuminous, clear solution one sow the yeast of beer rather than that of lactic acid, it is the yeast of beer that will develop and with it alcoholic fermentation, although there be no change in the other conditions of procedure. One must not infer from this that the chemical constitution of the two yeasts will be identical any more than that the chemical constitution of two vegetables is the same because they have lived on the same soil." In other words, he pointed out the specificity of these organisms and their specific physiological action. Finally, in an experiment of great beauty and simplicity he demonstrated the growth of micro-organisms with fermentation in a liquid free from organic nitrogenous matter.

"Alcohol fermentation," said he, "is an act related to life, with the organization of the globules (yeast), not with death or the putrefaction of these globules."

In connection with these studies he pointed out that, "Each cell of yeast has properties of species and of race which it shares with the neighboring cells, and, moreover, special characteristics of its own which it may transmit to its progeny." Thus he called attention to variations of species, and in the end gave to the manufacturers of beer the precious principle of the selection of yeasts.

In 1859 he was nominated administrator of the École normale and assistant director of scientific studies.

The development of a method designed to secure pure cultures from fluid media, the use of culture media of known composition, and the careful chemical study of products of decomposition all belong to this early period of Pasteur's life and were achievements of the deepest significance. . . .[4]

Butyric Acid Fermentation—Anaerobes

Upon these studies followed naturally the demonstration of the dependence of butyric acid fermentation on an organism which could develop only in the absence of free oxygen—the discovery of anaërobes. He showed how, in a fluid medium, the action of anaërobes follows that of the aërobes which use up the oxygen and by the film which they form on the surface of the liquids prevent its further entrance, thus preparing the way for the anaerobes in the depths.

Spontaneous Generation

Then, naturally (1860–1876), came the famous studies on spontaneous generation undertaken against the advice of his doubting masters, Biot and Dumas. On the basis of careful and well-conceived experiments he demonstrated the universal presence of bacteria in air, water, dust; he showed the variations in different regions of the bacterial content of the air; he demonstrated the permanent sterility of media protected from contamination, and he insisted on the inevitable derivation of every living organism from one of its kind. "No," he said, "there is no circumstance known to-day which justifies us in affirming that microscopic organisms have come into the world without germs, without parents like themselves. Those who make this assertion have been the playthings of illusions or ill-made experiments invalidated by errors which they have not been able to appreciate or to avoid." In the course of these experiments he demonstrated the necessity of reliable methods of sterilization for instruments or culture media, of exposure for half an hour to moist heat at 120° or to dry air at 180°. And behold! our modern procedures of sterilization and the basis of antiseptic surgery.

Studies on Vinegar

Then came the studies on vinegar, undertaken in an attempt to relieve the embarrassment of an important national industry, and the demonstration that the formation of vinegar was a process of oxidation and dependent upon the development of micro-organism, *Mycoderma aceti,* which forms a pellicle on the surface of the liquid and serves as a conveyor of oxygen from the air without to the alcohol within, from which it gains its sustenance. He resolved simply and practically all the important questions at issue in connection with the protection of the manufacturers of vinegar. In the course of his studies he showed that in the absence of alcohol, its diet of choice, *Mycoderma,* might go farther and attack and disintegrate the acetic acid, the product of its own creation. This not only explained certain annoying phenomena associated with vinegar production, but was the first demonstration of the ability of a living organism to destroy the product of its own development.

It is most interesting to note, by the way, that in

[3] 100th Anniversary of the Birth of Pasteur, Bulletin de l'Academie de médicine, 3, series, tome LXXXVIII.

[4] Herter, Johns Hopkins Hosp. Bull., 1903, XIV, 325.

studying enfeebled, "diseased" *mycoderma,* as he called it, he likened the oxidizing activity of the micro-organisms to that of the red corpuscles of the blood whose function it is to carry oxygen to the tissues, and asked himself what might happen in the human body if the diseased red blood corpuscles were inadequate to their task of oxidation.

Fascinating and interesting it is to see how, all along the way, his fertile, active mind sought the parallels between his observations and the diseases and injuries of man.

Certain manufacturers had taken advantage of his previous work and had secured patents for their own interest. To prevent the repetition of such a procedure before announcing a "new industrial procedure for the fabrication of vinegar" he took out a patent himself, and threw it open to the public.

DISEASES OF WINE

Then he passed to the studies of the diseases of wines (1865) which he found once more to be due to the development of living organisms. It was easy to prevent their development by sterilization, but how could this be done without destroying the wine? In the end he showed how the further development of the bacteria could be inhibited by rapid heating to 55° in closed vessels, at the proper period, and we have the process of *"Pasteurization!"*

DISEASES OF THE SILKWORM

The silkworm industry, so vital for France, was in sore distress. An epidemic disease increasing in severity was ruining the population of the south, who appealed to the government. Pasteur, a chemist, who knew nothing of the silkworm or its diseases, was requested to undertake the investigations into the nature of the disease and measures for its prevention. For six years, from 1865 to 1871, he gave his whole time to this work.

The silkworms, raised from the egg by exposure to gentle heat at the moment when the first leaves of the mulberry tree are opening, are covered immediately by young leaves upon which they feed. The worms seem to sleep as they clothe themselves with one skin after another from which, in succession, they moult. After the fourth moult, they pass through several days of extreme activity and voracity, following which they climb upon sprigs of heather carefully set out for them and form their cocoons. In the cocoons they remain for fifteen days. After this the moths emerge, sex-union occurs, and six hundred to eight hundred eggs are laid by each worm. If it be decided to use the cocoon for the manufacture of silk they are smothered in a vapor bath six or seven days after the worm has ascended the heather twigs. If, however, it be desired to collect eggs for the next brood, the emergence of the moth is awaited. When a brood appears especially good, through the regular development of its worms and the beauty of the cocoon, it is saved for its eggs.

For twenty years this disease had existed, and despite the importation of eggs from foreign countries, it had become worse and worse; it was known as Pebrine because of little, black, pepper-like spots which developed upon the diseased worms. In the diseased worms and in the eggs there had been found small, round corpuscles (psorosperms) which were regarded as evidence of the disease, and Osimo of Padua had already suggested that eggs should be saved for cultivation only from worms which did not contain corpuscles. But this measure had not been carried out with any regularity, and the true nature of the disease remained unknown.

In two years Pasteur solved the main problem. Although slow at first to recognize the infectious nature of the "corpuscles," he finally demonstrated that they were the infectious agents, that they might be introduced through the gastro-intestinal tract from leaves soiled by diseased worms; that they were hereditarily transmitted through infected eggs. He saw that the secret of protection lay in the microscopical examination of the moths at the time of their emergence from the cocoon, and that where more than 10 per cent. of these moths were "corpuscular," the eggs should not be used. By maintaining the cocoons at a temperature of 25° to 30° R, the emergence of the moths was hastened by five days. Test cocoons were submitted to high temperatures and where the number of diseased moths was too great, the attempt to collect the eggs was abandoned and the entire brood was used for the cocoon.

But this was not the whole story. Although, under these methods, the recovery of the silk industry seemed to be promised, yet there were puzzling circumstances. Sometimes the disease seemed to precede the appearance of the corpuscles; this might indeed occur in experimental infection of the worms. One day, with a despairing gesture, Pasteur announced to his colleagues that they must begin again; there were two diseases!

But in due time he solved the problem of the other disease, a sort of typhoid or cholera of the silkworm, due to organisms widespread in nature. This malady was generally transmitted from worm to worm through the sticky excrement shed by diseased animals upon the leaves upon which they fed. *Flacherie,* as it was called, occurred alongside of *Pebrine* and had thus caused considerable confusion. Flacherie also was an hereditary disease.

With this knowledge the necessary prophylactic measures were soon devised. Pasteur had but to add to his former directions: "One should never use for

eggs broods which have shown from the fourth moult to the cocoon, any languishing worms, or which have shown definite evidences of flacherie," and the silkworm industry was saved.

In the course of these studies Pasteur made observations of great interest. He found, for instance, that the period of incubation of the disease varied according to different circumstances; that when the infectious agent was carried from worm to worm through a series, the period of incubation was shortened. Repeated passages of the parasite through successive hosts increased its virulence.

He noted the difference between the period of incubation in worms infected by means of hypodermic injections and those acquiring the disease in the usual manner—*the influence on the period of incubation of the portal of entry:* he recognized that although the infectious agent was widespread, almost always present, the disease did not always arise; some worms seemed to resist infection—in other words, there were *variations in resistance and susceptibility of the host.*

As Duclaux says, he had brought the great questions of contagion and heredity into the field of experiment.

At about this time, the study of a mould, *Mucor mucedo,* led him to appreciate the *possibility of the anaërobic life of aërobic species and the variations in form of an organism which may accompany the variations of the media in which it lives.*

He then returned to his studies of wine, led by the desire to discover whence came the organisms which caused the alcoholic fermentation of grapes. By simple but ingeniously devised experiments, he showed that these organisms, *Saccharomyces,* were widely distributed and were to be found on the surface of the individual grapes. But they appeared only at a definite time in the development of the grape, at a fixed season of the year. On the other hand, the *mucor* parasites capable also of producing a fermentation were present at all times in the soil.

And his alert mind, ever seeking analogies between these processes in the vegetable kingdom and human disease, led him to these prophetic reflections:

> May we not, by analogy, be justified in the belief that one day simple and easily applied measures of prevention will arrest these scourges which at one blow desolate and terrify whole populations such as the terrible disease (yellow fever) which has recently invaded Senegal and the Valley of the Mississippi, or that other (bubonic plague), more terrible perhaps, which has raged on the banks of the Volga?

In 1874 there came to Pasteur from Edinburgh a grateful and appreciative letter from Joseph Lister, who called attention to the beneficent results which had followed the application of his principles, scrupulous cleanliness, antisepsis, to the practise of surgery.

An era had passed—the old black era of helplessness and uncertainty, of cruel doubt and hope deceived. The hand of the surgeon was freed.

Anthrax

While the old controversies concerning fermentations and spontaneous generation still continued, the victory was already won, and more and more Pasteur's mind turned towards the practical application of his discoveries to diseases of higher animals and man. For this, as Duclaux has so clearly pointed out, he was well prepared. His demonstration of the specificity of micro-organisms, his observations on their life history, and especially of their nutritive demands, his studies concerning the increase and diminution of virulence, of the variation, under different conditions, of the resistance of the host to infection—all these observations and conceptions had taken root in his mind and it is but natural that he should have turned to the study of infectious diseases in the higher animals.

In 1877, he began the study of anthrax—a cruel disease, fatal to sheep and cattle, especially the former. Sometimes nearly half a flock died in one season. There were special regions which seemed fatal, fields or hillsides on which sheep might not feed, over which they might not pass without acquiring the disease. To what was this due? For many years (Delafond, 1838) the existence of little rodlets in the blood of animals dead of anthrax had been known and the question as to the infectious nature of these rodlets had been raised (Davaine, 1850). Pasteur had discovered resistant spores in the bacillus of Flacherie, structures destined to preserve the life of the organism through long periods under adverse conditions. Koch, but a year before, had pointed out like spores in the bacillus of anthrax. More than this, Koch had cultivated the bacilli in the aqueous humor of the eye and in fresh drops of the blood serum of the ox. These cultures he had carried through eight generations, and from them he had transmitted the disease to small animals. But some objectors still raised the question as to whether he might not have carried over some vague virus from one to another of these small cultures.

Pasteur cultivated the bacillus in flasks containing fifty cc of neutral or slightly alkaline urine and succeeded in carrying on these cultures indefinitely from generation to generation. The tenth generation was as capable of transferring the disease as the first. Here one could hardly imagine the transference of a virus other than the bacterium. Fowls were refractory to the disease.

Gas Gangrene

During Pacteur's studies concerning the specificity

of the bacillus of anthrax, other observers in carrying out inoculations from animals dead with the disease had produced a fatal illness without the presence of the bacteridia. Pasteur discovered in the blood of these animals another organism, a long bacillus, found normally in great numbers in the intestinal tract, which, after death, might enter the blood and develop more rapidly than does the organism of anthrax. When both organisms were introduced at the same time the animal died from septicaemia due to the multiplication of the other bacteridium which he called *Vibrio septique,* before *Bacillus anthracis* had time to grow. The new organism, closely allied to the so-called gas bacillus of Welch, was anaërobic and produced gas in the tissues of the animal infected—the familiar gas gangrene.

In a communication to the Academy of Medicine made on April 30, 1878, Pasteur points out the danger of the entry of such organisms into the tissues, their relation to surgical gangrene, and insists on the importance of antisepsis in surgery. These are his closing words:

> A few weeks ago one of the members of the section on medicine and surgery of the Academy of Sciences, M. M. Sédilot, after having meditated long on that which he had learned in a brilliant career, found a rational explanation in the principles on which rest the so-called germ theory, and that this would give rise to a new surgery, already inaugurated by a celebrated English surgeon, Dr. Lister, who, one of the first, had comprehended its fecundity. Without professional competency, but with the conviction of the qualified experimenter, I shall dare here to repeat the words of our eminent confrère.

These were busy days in which Pasteur's vision, penetrating into many vistas, was constantly making fresh observations and new discoveries.

Fowls he had found resistant to anthrax. But the organism of anthrax is readily killed at high temperatures, and the ordinary temperature of a hen is 43° or 44° C. If the lower third of the body of a fowl be held immersed in water at 25°, the body temperature may be lowered to that of man or those animals susceptible to anthrax. But introduced into a hen with lowered temperature, the bacillus throve and multiplied, and the fowl died.

STAPHYLOCOCCI AND STREPTOCOCCI

New observations succeeded one another in rapid succession. In 1879, Pasteur discovered in abscesses of the skin little round organisms which grew in clumps like bunches of grapes, whence the name, Staphylococci, and later he found the same organisms in an instance of osteo-myelitis, which, forthwith and quite properly, he called an "abscess of the bone-marrow."

In the *maternité* he found similar round organisms, arranged, however, in chains (Streptococci) in the lochia of women with puerperal fever and in the diseased tissues of those who had died, and he suspected immediately that this organism was the cause of the disease.

At a meeting of the Academy in a discussion on puerperal fever, Pasteur, impatient, interrupted the speaker. "That has nothing to do with the cause of the epidemic; it is the doctor and his personnel who carry the germs from a diseased to a healthy woman." And when the orator replied that he doubted whether such an organism would ever be seen, Pasteur dashed to the blackboard and figuring a chain of streptococci, exclaimed, "There, behold its picture."

In 1806 at the *maternité* one woman in four died of infection; to-day at the Baudeloque (Calmette) the mortality is one in two thousand.

In the words of Descour, "Thanks to Pasteur, maternity hosiptals are no longer ante-chambers of death."

CHICKEN CHOLERA—VACCINATION

Next, Pasteur took up the study of a disease of poultry, chicken cholera, a disastrous epidemic malady which played havoc in the poultry yards. A parasite had been discovered by others and suspected of being the cause of the disease. Toussaint had shown that the disease could be transmitted by the blood of the diseased chicken; but he had failed in his efforts to cultivate the germ. He sent Pasteur the head of a cock dead of chicken cholera. Pasteur found the small bacillus which failed to grow in ordinary media but developed rapidly upon that which his insight soon suggested, a broth made of the muscles of the chicken itself. The infectious agent entered by the gastro-intestinal tract, passed out through the excrement and was thus scattered about the poultry yards.

In guinea pigs the organisms of chicken cholera produced only local abscesses, but retained their virulence; and Pasteur pointed out how such infected pigs might, through discharging abscesses, spread the disease—the first example of carriers.

One day, after a vacation, he inoculated some fowls with an old culture which had stood, untouched, for some weeks; the birds were but slightly ill—and recovered. What had happened? He inoculated the same fowls with fresh cultures; they remained unaffected. But fresh fowls, inoculated for the first time with these same cultures, died in the usual manner. The old cultures had lost their strength. *Inoculation with these old, attenuated cultures had conferred immunity!* Pasteur had made his greatest discovery, that of the possibility of preventive vaccination!

It was no mere accident. To his prepared mind the experiment had immediately suggested itself. The

analogy with Jenner's vaccination against smallpox was instantly grasped—an analogy in a disease known to be due to a micro-organism! The attenuation of the virulence of the cultures depended on their age. According to the age of the cultures, every degree of attenuation could be obtained. The characteristics of each generation of cultures were hereditary and fixed. Pasteur, as Roux has said, obtained races of virus as gardeners obtained races of flowers.

It was not so much that a method of preventing a disastrous disease of poultry yards had been found; the door had been opened.

Pasteur had meditated and speculated on many possibilities. Among other things he had noted that in certain cases, instead of killing rapidly, chicken cholera passes into a chronic state, the fowls succumbing only after weeks and months of languor. But when the parasite is grown from these birds, its virulence, contrary to what one might expect, is exalted to a maximal degree. And he observed that this interesting example of the combat between host and parasite found an analogy in those instances of rabies with long periods of incubation. Rabies already was in his mind. He was ever reaching for analogies. Among his papers of this period is a project for the study of plague such as that later and so fruitfully carried out by his pupil, Yersin.

Prophylaxis of Anthrax

At the same time Pasteur was still pondering upon the subject of anthrax. The neighborhood of a pit in which diseased animals were buried was notably dangerous. He had demonstrated living spores on the surface of the earth as long as twelve years after burial of the animals. How could these spores on the surface of the earth stand the dispersing influences of wind and rain? Where did they come from? Could it be that they arose from the depths? If so, how?

One day while walking in such a field freshly harvested, he noticed certain spots which differed from others in colour. These were the areas in which diseased animals had been buried. He examined them closely. The soil was thickly covered with the castings of earth worms; and the truth flashed upon him. It was the earth worm in its silent labor of aëration and drainage of the soil, burrowing to the depths and bringing again to the surface those particles which it deposits in its little spiral castings, it was the earth worm that brought to the surface again the spores of anthrax. He demonstrated spores in worms and in castings—and straightway an important measure of prophylaxis became apparent, namely, that diseased animals, if they could not be disposed of otherwise, should be buried only in dry, barren, sandy soil.

Vaccination against Anthrax

The minister of agriculture demanded that Pasteur investigate a method of treatment of anthrax introduced by a veterinarian in the Jura. In the course of this study he was given two cows which had recovered from the disease. They resisted inoculation with virulent cultures. They were immune. Vaccination was possible. But how produce the vaccine? The spore-producing characteristics of the anthrax bacillus rendered this procedure difficult and puzzling. The organism does not grow at temperatures above 44°. Between 42° and 43°, however, the spores are no longer formed. If cultures are kept at this temperature for about a month, the time comes when they cease to grow on transference. With the age of the culture, virulence for sheep, rabbits and guinea pigs diminishes rapidly and progressively until it disappears. The characteristics of the organism at each age are stable, but the virulence may be raised immediately by passing them again through successive living subjects, beginning with the young, which are most susceptible, and passing the organisms through successively older animals. The analogy with the bacillus of chicken cholera was complete. Might not the cause of some spontaneous epidemics be the reëstablishment of virulence in an organism which had reached a degree of attenuation so great as to be almost if not quite innocuous?

It was but a step to vaccination against anthrax with attenuated cultures. And when he was ready, the efficiency of the measure was demonstrated in dramatic fashion. Before a large audience, fifty sheep were inoculated with a highly virulent culture of anthrax. Twenty-five of these sheep had previously been vaccinated with attenuated cultures. The non-vaccinated sheep all died; the vaccinated all recovered. A reliable measure of prophylaxis against anthrax had been established.

Swine Fever

In March, 1882, Thuillier, at Pasteur's request, began the study of swine fever, a fatal and widespread disease. The pathogenic organism, a small bacillus, was soon isolated. Pasteur remembered his observations on the organism of rabbit septicæmia which he had found a year or so before in the saliva of a child with rabies. Although harmless for old guinea pigs, this organism was virulent for the young. Passed through a series of young animals, the virulence was so far raised that it became pathogenic for the old as well. But he had made this striking observation: *In the course of its passage through guinea pigs the organism had lost its virulence for rabbits.* In these regions where swine fever pre-

vailed, epidemics were frequent among pigeons and rabbits. The bacillus of swine fever killed pigeons rapidly and by passing the organism through a series of pigeons, its virulence, both for pigeons and for swine, could be raised to a degree considerably above that attained by strains carried alone from hog to hog. The same bacillus killed rabbits, but, although on successive passages through rabbits its virulence was augmented for them, the virulence for swine became progressively diminished, so that in the end an attenuated organism was obtained—capable of transmitting to swine a mild disease only, from which they recovered with an immunity lasting at least a year. A method of vaccination was at hand. Swine fever in its turn was conquered.

RABIES

That the mystery and the hopelessness of rabies had long been in Pasteur's mind is clear from the occasional references to the disease that appear in his earlier studies.

In 1880 the opportunity came to observe a patient in the wards of Lannelongue. From the sputa, as has been mentioned, he had obtained the bacterium of rabbit septicaemia which later turned out to be the pneumococcus of Fraenkel. All further attempts to cultivate a pathogenic organism failed. By introducing subcutaneously bits of the central nervous system, he had transferred the disease, but the period of incubation was distressingly long and uncertain, amounting sometimes to months.

Finally, by introducing bits of the substance of the medulla of affected animals under the dura mater of the brain, he succeeded in transmitting the disease with certainty, with an average incubation period of about fourteen days.

And then, guided by his experience with other organisms, which he had studied, he succeeded, by repeated passage from rabbit to rabbit, in obtaining a virus of great strength and of an incubation period of a maximum of seven days.

By passage through monkeys the virus could be attenuated to such a degree as to be nearly harmless on subdural introduction into the dog. *These injections conferred immunity.*

He reflected on the long incubation period following the bite and the short period which elapsed between the inoculation and the outbreak of the disease when the strong virus from rabbits was used. Might one not, by subjecting the cords of these rabbits to the action of oxygen in dry air, produce an attenuated virus which would yield a safe vaccine? And with such a vaccine with a short period of incubation, might one not hope, even after the patient was bitten, to produce immunity against the more slowly developing virus introduced by the bite?

Cords of rabbits dead with malignant rabies of an incubation of seven days were subjected to the action of oxygen in jars containing a little caustic potash. Attenuation was readily obtained.[5] By subcutaneous injection daily of bits of these cords of progressively increasing virulence, it was possible to immunize dogs to the most virulent material even if introduced under the membranes of the brain.

At this point in his studies there was brought to his laboratory a little Alsatian boy who, sixty hours before, had been terribly bitten by an obviously mad dog—bitten in such a manner that the development of the disease seemed certain.

Pasteur took counsel with his friends, and acted. He suffered, in silence, cruel anxiety. In nine days the little boy had finished his treatment and had received, finally, injections of the most virulent material, material tested step by step on control animals. The boy was saved. Others followed. The almost universal success of the treatment if begun early, was proven beyond a peradventure.

In 36 years, out of nearly 45,000 patients brought to the laboratory at various periods after the bite, the mortality had been but three per thousand.

The name of the master and the fame of his accomplishments were on the lips of all the world. Honors poured upon him. National subscription built the Institute, that Institute of which he has said: "There is not a stone which is not the material evidence of a generous thought," and there and in all lands thousands of his disciples continue the work that he initiated.

This, in brief, is the story of Pasteur's contributions to medicine.

And the man?

An artistic nature, gifted with powers of design that, early in life, seemed to point to another career.

A sensitive, poetic spirit which betrays itself again and again in the charm of his language. But the emotions of the artist and the poet were controlled by an overpowering love of truth and the censorship, in matters of science, of a Puritan conscience.

He was a noble example of the disinterested student. When asked by the emperor why he sought no material advantage from his discoveries he replied: "In France men of science would consider such an act unworthy."

He was intensely human—human, if one may say so, in his very humanity, for with all his love of pure science, he was forever asking himself how he might use his achievements for the benefit of his country and his fellows; human in his tender-heartedness and gentleness and love for animals; human in his impatience toward opposition, for he was not always patient.

[5] In the sense, possibly, only of a diminution in the *number* of organisms.

under criticism, especially if that criticism were born of prejudice or supported by careless or ill-formulated experiments or observation—against such opposition his polemics were sharp; nor in hours of work was he especially tolerant of those futile interruptions which are the despair of the student; human in his devotion to his parents and to his family, and in his profound patriotism.

From the foundation of the institute to the day of his death, in 1895, his quiet life among his friends and his students in the laboratory was a long triumph. As it has been said of Jeanne d'Arc, so was it true of Pasteur—he had become a legend while yet he lived.

Early in his career he had risen again from a physical blow that too often saps the vigour and initiative of the strongest. The "God within" carried him forward and onward over obstacles and through trials that would have baffled another.

Now, he was tired. The loving homage of grateful humanity was almost a burden. But he lived to see the first of the harvest, and he died with the world at his feet.

In the 40 years of his active life Pasteur laid the basis of our knowledge of infections and infectious agents from which such inestimable blessings have flowed; he "revivified the biological sciences" (Herter), but more than this, as Widal has well said, he introduced into medicine accuracy and precision of technique and the habit of experimentation—"the realization of the necessity of precision and the means of satisfying it."

From the seed that he sowed, what a harvest has come forth! Improvements of technique introduced even during his life time have brought increasing certainty and accuracy into our methods. One after another the plagues of humanity are yielding their secrets to inquiring students. The questions of immunity and susceptibility on which he had but begun to ponder have expanded into profound and complicated problems which for their explanations are turning us more and more back to the fundamental chemical and physical principles with which he began.

The scope of preventive medicine, which, one might almost say, began with Jenner and Pasteur, has widened until problems of public hygiene have become, throughout the world, matters of civic, national, international concern.

And finally, as Calmette has said:

Dans l'ordre social l'oeuvre de Pasteur n'a pas été moins féconde. En nous faisant connaître la cause des maladies, en nous montrant que ces causes sont justiciables de notre intervention, elle a complètement modifié les anciennes conceptions du devoir social vis-à-vis des malades.

Cet ensemble de notions nouvelles, derivées de l'oeuvre de Pasteur et imposées à nos consciences par les sentiments plus vifs de solidarité que dévelope la civilization, constitue ce que nous appelons l'hygiène sociale. On peut envisager celle-ci comme la base même de la politique, science encore au berceau, quoique née déjà bien des siècles avant Aristote, mais science qui a ou plutôt qui devrait avoir pour essentiel object la conduite des peuples.[6]

Prophetic words! To-day in a world distracted, crippled, poisoned by the venom of war, there has risen one star of real hope—those efforts under the League of Nations, through the activities of the International Red Cross, to extend this work of Social Hygiene in its broadest sense. In this one field all have joined hands. In this one field jealousies, suspicions, selfishness, self-interest, are drowned in a common will to unite in combating the ravages of disease; in making the world a safer, better place to live in, that man may be stronger, wiser, saner; that the future may be spared some of the tragedies that we have known.

How far these beginnings may lead, we know not, for the future is veiled from the eyes of men. But this we know; they can lead only to better days.

The world is one in its will to strive for the continuation of the work of Pasteur.

France gave to the world this man—France, to whom humanity and civilization owe so much of that on which they rest—France, serene, wise, radiant with the beauty that was Greece—France, to whom we of the western world owe our existence as a nation—We salute you in the name of your greatest son! Through him you have laid the foundations of the true science of politics that shall one day bring a fuller measure of peace and happiness to a troubled world!

WILLIAM SYDNEY THAYER

REPLY TO AMERICA

A HALF century ago on the other side of the Atlantic a nation began to take cognizance of itself, young, confident in its healthy vigour, impatient in its forward march, reaching out eagerly towards the future, knowing no obstacle to its will to attain generous ends.

[6] "From a social standpoint the work of Pasteur has been no less fruitful. In revealing to us the causes of disease, in showing us that these causes may be controlled, it has profoundly modified the old conceptions of the duty of society to the sick.

"This body of new conceptions springing from the work of Pasteur and imposed on our conscience by the more acute sense of solidarity developed by civilization constitutes that which we call social hygiene. This one may regard as the very corner-stone of politics, a science yet in its cradle, although born centuries before Aristotle; a science, however, the essential object of which is, or rather should be, the conduct of peoples."

One of its own poets[1] prophetically said: ". . . ,

Whence to arise inevitable in time, the towering roofs, the lamps,
The solid-planted spires tall shooting to the stars."

And soon Europe felt herself fanned by the breath which from the Pacific to the Atlantic animated the new world. America brought a new youth to the universe.

At the same time there arose on the soil of France a man whose genius was to penetrate to the very foundations of life and to liberate humanity from the bonds which enslaved it to deadly plagues. This man who had made himself—a "self-made man" according to your fine expression—was gifted with most exceptional virtues, without which he could not have built up the gigantic structure of his work which was to be the greatest revolution in the domain of the mind that the world had ever known.

Enthusiasm dominated his character and magnified his life. He had faith in his mission. He went straight to his end towards the great horizons that his genius divined already at the age of 26. His poetic imagination gave wings to his thought, but he knew how to discipline himself, and, by a severe control, to become his own implacable adversary. Tenacious, indefatigable in his pursuit of truth, he knew not discouragement and repeated continually to his disciples: "No effort is lost." Skepticism alone was hateful to him and to his fascinating spirit. His mind full of speculations, the most prodigious that had issued from the human brain had, always practical realizations for its goal, for he was ever obsessed by a sense of duty to render service and considered science as a dispenser of blessings. He was audacious and like all great leaders of men he knew how to play his all at the decisive moment. He was attracted by all that is great and beautiful. His motto was: "Look upwards, peer into the beyond, seek always to raise yourself." He loved his country with a passionate love, and wished that upon her might shine the lustre of his discoveries; but he did not distingiush love of country from love of humanity. His generous soul looked toward the intellectual and moral union of all nations. His pity covered the world, that pity forever active which prompted him to say: "One does not ask of an unfortunate, 'Of what country or of what religion are you?' One says to him: 'You suffer.' That is enough; you are mine, and I will help you.'"

America recognized herself in this son of France. All the virtues that make peoples great, these she found united in him. She took him for model and guide. He became her ideal.

From his laboratory in the École Normale, empty, without endowment, without credit, Pasteur had written: "Concern yourselves, I beg of you, with these sacred dwellings that we designate with the expressive term, *laboratories*. Demand that they be multiplied, that they be adorned; these are the temples of the future; the temples of wealth and happiness. There it is that humanity grows and becomes better. There it learns to read in the atcivities of nature manifestations of progress and universal harmony, while these activities of themselves are too often those of barbarism, fanaticism and destruction."

Then one saw rising on the soil of America, on every side, universities and professional schools such as the Johns Hopkins, great laboratories, those admirable institutions such as the Rockefeller Institution, which are your pride and your glory. The dream of Pasteur became a reality and more. Your laboratories were animated by the intellectual sons of Pasteur, Flexner, Theobald Smith, Noguchi, Carrel, MacCallum, Loeb and so many others. Their discoveries were the offspring of the methods of Pasteur. All Pasteur's discoveries in chemistry, in agriculture, in medicine, in hygiene, America applied them and developed them. Deadly epidemics she knew no more. Her children by thousands were snatched from the clutches of death. She pushed back the limits of human life and diminished suffering. Her unhealthy spots were transformed into prosperous regions. She became the land of promise that we coveted. In a few years she realized an expansion such as one had not seen in the history of mankind. No conception seemed too daring for her. With her realization kept pace with thought. Her most audacious enterprises were so many successes.

Perseverance in effort, tenacity in the pursuit of the end to be attained, certitude that all is possible to him who knows how to will; enthusiasm for all causes that were just and true; love of country combined with love of humanity; all the guiding qualities of Pasteur, your children reached out to grasp them. And before your universities, in your public places, in your laboratories and your hospitals and your colleges, everywhere stands the tutelary effigy of him whom you venerate.

How deep was my emotion, 18 months ago, when I found in your country that cult of Pasteur, a cult springing from comprehension, admiration and love! You who came to fight by the side of that people which gave Pasteur to the world, it was your desire some months ago in Philadelphia, in New York, in Chicago, it was your desire to-day in this ceremony which will remain dear to all Frenchmen, that your hearts should once more thrill in unison with ours, and—one of those touching thoughts which are so characteristic of you—you have sent two of your distinguished pathologists whom we venerate and love, Professor Welch and Professor Thayer, to celebrate our Pasteur, who is yours, too.

In this hymn of gratitude which has been rising

[1] Walt Whitman: "Leaves of Grass."

from all nations for the last six months—that which Pasteur would have appreciated beyond all—it is as a resurgence of hope of humanity for peace and concord among the peoples of the world. And at this moment does it not seem to you, gentlemen, that Pasteur is here among us, as he was thirty years ago on his seventieth anniversary? Do you not hear him say to you as he did then, those words which should become a reality: "You bring me the deepest joy that can come to a man who believes invincibly that science and peace will triumph over ignorance and war, that the peoples of the world will come together, not to destroy but to build, and that the future is to those who have rendered the greatest service to suffering humanity."

PASTEUR VALLÉRY-RADOT
PARIS, FRANCE

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE CINCINNATI MEETING

PREPARATIONS for the third Cincinnati meeting, which will celebrate the seventy-fifth anniversary of the founding of the association, are in an advanced stage. The meeting is to open on Thursday, December 27, and will close on Wednesday, January 2. The general secretary and the permanent secretary recently visited Cincinnati and conferred with members of the local committee that has charge of preliminary arrangements. The local committee, under the able chairmanship of Professor Louis T. More, has everything well in hand. Especially has Professor Edgar Dow Gilman, secretary of the committee, rendered very efficient and invaluable service to the association and to the thirty societies that are to meet with the association at Cincinnati. Nearly all the meeting rooms have already been assigned, and arrangements have been made for the several general sessions, for the exhibition of apparatus, etc., and for the registration offices.

The preliminary announcement of the approaching meeting, a booklet of eighty-five pages, has just been issued from the permanent secretary's office. Copies have been sent to all members of the association and to others who are members of societies that are to take part—as far as the requisite lists have been furnished by the societies. The booklet contains more information concerning the approaching meeting than has been possible in the case of any similar announcement in past years. Also, it has been possible to publish this announcement earlier than in recent years, because of improving cooperation among the Washington office, the local committee and the section and society secretaries and committees.

The most important message carried by the announcement is perhaps the statement that reduced railway rates are available for those who are to attend, from practically the whole of the United States and Canada. These are to be secured on the certificate plan, as in recent years. A first-class, full-fare, one-way ticket to Cincinnati should be purchased and a *certificate* for the American Association for the Advancement of Science meeting, on *standard certificate form*, should be secured. The certificate is to be left at the validation desk in the registration room, upon arrival; it will be endorsed and validated without further attention from its owner and may be secured at the same desk on a later day. The railway agents at Cincinnati will sell each holder of an endorsed and validated certificate a continuous-passage return ticket for one half of the regular fare, by the same route as that followed in the trip to Cincinnati. Thus the round-trip will cost those who attend the meeting an amount equal to one and one half times the regular one-way fare. This privilege will be available to all who are members or associates of the association in good standing, or who are members of any society or organization meeting with the association at this time, or who are members of any society officially associated or affiliated with the association, or who are delegates from institutions or personal guests of persons entitled to reduced rates. Registration will be necessary in order to secure the reduced railway rates, and all who register will receive the badge for the meeting and a copy of the general program.

Several new features will characterize the seventy-fifth anniversary meeting. There will be a prize of one thousand dollars awarded to some person presenting a notable contribution to the advancement of science, either before the association as such or before one of the societies. It is planned that several supplements to the general program will be issued as the meeting proceeds, thus bringing to publication any program material that may be received too late for inclusion in the regular edition, additions, corrections, etc. An exhibition of scientific apparatus, products and books is being arranged and a good number of exhibits are already entered. It is hoped that the exhibition may be a very important feature of this meeting and that future exhibitions may be of progressively greater importance. Those desiring to enter exhibits should make arrangements with Professor R. E. Oesper, chairman of the sub-committee on exhibition, the University of Cincinnati. Professer Oesper has given much time and attention to preparations for this feature of the meeting. The association's collection of portraits and autograph letters of its past presidents will be exhibited for the first time at Cincinnati.

The opening session will occur on Thursday evening, December 27, under the presidency of Dr. Charles D. Walcott, secretary of the Smithsonian Institution.

The lecture of the evening will be given by Dr. J. Playfair McMurrich, of the University of Toronto, who is retiring president of the association.

On Friday afternoon, Mrs. Charles D. Walcott, of Washington, will show some of a fine collection of lantern slides colored by herself, from photographs she has taken of wild flowers of the Canadian Rockies. Mrs. Walcott will give explanations and present observations on the habitats of the plants represented. She has spent many years in the preparation of these slides.

The second annual Sigma Xi lecture, under the joint auspices of the association and the society of Sigma Xi, will be given on Friday evening, December 28, in the auditorium of the Hughes High School, by Dr. Willis Rodney Whitney, director of the research laboratory of the General Electric Company, Schenectady. The topic of the lecture is to be "The Vacuum, There's Something in It," and it will be illustrated by experimental demonstrations of the latest developments in the field of vacuum tubes.

In celebration of the seventy-fifth anniversary, the Saturday evening session is to be devoted to short addresses by a number of past presidents of the association. Dr. T. C. Mendenhall and Dr. T. C. Chamberlin are among the older past presidents who expect to be present. It is regretted that Professor Edward S. Morse, the past president of longest standing, will not be able to attend, but it is hoped that a letter from him may be read.

An important paper on the history of the association is to be read by Dr. Herman L. Fairchild, emeritus professor of geology in the University of Rochester. This will probably occur on Saturday afternoon. It is expected that Dr. Nevin M. Fenneman, professor of geology and geography in the University of Cincinnati, will deliver a lecture on the geology of the Cincinnati region, illustrated with lantern slides. This is planned for Monday evening.

A complimentary concert by the Cincinnati Symphony Orchestra on Sunday afternoon will be a very attractive feature of the meeting. A general reception to those in attendance will be given by the University of Cincinnati on Thursday evening, following the opening session.

The preliminary announcement contains the usual list of hotels and their rates. The general headquarters of the association will be at the Hotel Sinton, where many of the societies also will have their headquarters. Other societies are to have headquarters at the Hotel Gibson and other hotels. Those who desire hotel accommodations for the meeting should engage them at once by writing to the hotel.

Very excellent arrangements have been made for daily luncheons, in the cafeterias of the university and of Hughes High School, in the vicinity.

Every person whose name occurs as author of a paper on the program, as the information reaches the Washington office, is being requested, by special letter, to send to Science Service, 1115 Connecticut Ave., Washington, D. C., a brief and clear abstract of his paper. These abstracts will be used by Science Service and the publicity committee for the meeting. It is hoped that all who receive these requests will respond very promptly, so that the publicity work may be largely completed in advance. In recent years the association meetings have been given increasingly satisfactory publicity service by the daily press throughout the country. Those who are to present papers are urged to help in this important aspect of the meeting by not failing to supply Science Service with suitable abstracts of their contributions. The material of any paper will not be released until the day on which the paper is to be read.

Persons attending the meeting may have mail, etc., addressed to them in care of the American Association for the Advancement of Science, Registration room, Women's Building, University of Cincinnati.

The section organizations of the association, and the numerous scientific societies that are to meet with the association this year, will hold numerous sessions for the reading of papers and the delivering of addresses, by leaders and specialists in nearly all branches of science. Sixteen pages of the preliminary announcement are devoted to a summary account of these sessions. The American Mathematical Society (Chicago Section) and the Mathematical Association of America will meet with Section A. The American Physical Society and the American Meteorological Society will meet with Section B. The first joint intersectional meeting of the American Chemical Society with Section C will occur at Cincinnati. It has now been several years since the American Chemical Society has appeared in the chemical programs of the annual gatherings of the association and it is expected that the cooperation of the society will add much to the interest and value of this meeting. Astronomy will be represented by several sessions of Section D, and geology and geography will be represented by an unusually fine program of Section E, as well as by the sessions of the Association of American Geographers and the National Council of Geography Teachers. The American Society of Zoologists, the Entomological Society of America, the American Association of Economic Entomologists, and the Wilson Ornithological Club, will all hold many important sessions devoted to zoological science. Botanical sciences will be cared for by sessions of Section G and of the Botanical Society of America and the American Phytopathological Society. The American Society of Naturalists, the Ecological Society of America and the American Nature-Study Society will

hold important sessions in connection with Sections F and G. There will be sessions of Section H and an Anthropologists' dinner. There will be a session devoted to intelligence tests by Section I. Section K will present several sessions on the general topic, "Social and Economic Progress since the War." The Metric Association will hold its annual meeting and dinner. The history of science will be well represented at the seventy-fifth anniversary meeting, not only by special sessions on this subject under Section L, but also by many papers and addresses in the various sections and societies. A special program and conference on philological sciences is being arranged, also under Section L, and a session on auxiliary language is being planned. In connection with Section L the National Association of Teachers of Speech will hold its annual meeting, with some specially important features. A session will be devoted to engineering by Section M. Two sessions have been arranged on scientific questions related to medicine by Section N. Agriculture will be represented by sessions of Section O and the American Society of Agronomy, the American Society for Horticultural Science, the Potato Association of America and the Association of Official Seed Analysts. Section Q will hold several sessions on education, with important programs.

The preliminary announcement includes the usual lists of association officers, council members, committees, etc.

Business to come before the council or the executive committee at Cincinnati should be in the hands of the permanent secretary by December 20. The executive committee will hold a session on Wednesday evening and another on Thursday forenoon. The council will hold its main session on Thursday afternoon. The secretaries of the sections and the members of the executive committee are to meet and dine together Sunday evening.

The third Cincinnati meeting promises to be one of the most important meetings in the history of the association and it will surely be worthy of its special characterization as the seventy-fifth anniversary meeting. All who are interested in the progress of science and education, who are not to attend other scientific meetings occurring in convocation week this year, should not fail to come to Cincinnati.

BURTON E. LIVINGSTON,
Permanent Secretary.

SCIENTIFIC EVENTS

THE IMPERIAL INSTITUTE

WE learn from the London *Times* that the report of the committee appointed (under the chairmanship of Mr. Ormsby-Gore) to inquire into the activities of the Imperial Institute and the resolutions passed by the Imperial Economic Conference on considering that report have been issued as a White Paper. After a review of the history and work of the institute the committee declare:

> The founders' conception of one great Imperial organization displaying all the resources of the empire and advancing the work of empire development in scientific and industrial research and in technical and commercial education was a memorable one. At the present day, however, it seems to us that the existence of such an institution is no longer within the bounds of practical possibility. The rapid advance of the Dominions as self-governing communities within the empire, the wonderful developments in commerce and industry, the great progress in science and the ever-increasing complexity of mechanical inventions during the last generation, and the growth of numerous departments of state and of various public and semi-official institutions engaged in specialized research of one form or another have all tended to make the aims of such a central organization as the institute was originally meant to be impossible of achievement.

The committee recommended that the institute should discontinue the attempt to illustrate by means of exhibition galleries the natural resources of the empire, and that a really representative selection of empire products be made for the purpose of a traveling exhibition of a purely educational character, and that the possibility of organizing traveling exhibitions of the staple products of the colonies and protectorates in the appropriate trade centers should be considered.

The Imperial Institute should, however, continue to function at South Kensington as a clearing house of intelligence and information, equipped with laboratories to enable it to carry on only the work of preliminary analysis and investigation of raw materials. All inquiries entailing elaborate investigation or real scientific research should be referred to the competent authorities. Reliable up-to-date sample rooms, illustrative of important empire raw materials, should be maintained.

Recommendations were also made as to the future management of the institute, and the scheme was made dependent upon the support of the oversea governments being promised for a definite period. The annual cost of the institute under the committee's scheme is estimated at about £40,000 a year. The complete amalgamation of the Imperial Mineral Resources Bureau and the institute was advocated, and it was proposed that the institute should be made responsible to the Department of Overseas Trade. Failing the support of oversea governments, an alternative scheme was drawn up by which the institute could carry on the most essential feature of its present work—*i.e.*, that of an intelligence and informa-

tion bureau, without laboratories.

In view of the changes in the constitution of the Imperial Institute which have been decided upon, Professor Wyndham R. Dunstan, F.R.S., will resign the directorship of the institute next month, to which he was appointed in 1903.

ENGLISH VITAL STATISTICS[1]

THE registrar-general's statistical review of England and Wales for 1922, which has just been published, shows the lowest birth rate recorded in any year, save the war years 1917–1919; the lowest death rate, except in 1920 and 1921, and the lowest infant mortality ever recorded.

Births numbered 780,124, equivalent to a rate of 20.4 per thousand living, and were fewer by 68,690 than in 1921. Excluding the three years mentioned, we have to go back as far as 1869 to find a year in which the births reached so low a figure, and at that date the population was only 22,000,000, against 38,000,000 in the year under review. Before the war, the male births were in proportion of 1,038 to 1,000 female births. From 1916 onward, however, the plurality of males showed a decided increase, the average for the five years from 1916 to 1920 being as high as 1,051, at which figure it remained in 1921. Last year the proportion fell slightly, to 1,049, but it is still, as will be seen, considerably in excess of the prewar figure. The proportion of illegitimate to total births fell slightly, from 45 per thousand in 1921 to 44 in 1922.

Deaths numbered 486,229, equivalent to a rate of 12.8 per thousand living, and were 27,600 more than in 1921, when the lowest death rate (12.1) was recorded. If the population is standardized to the sex and age constitution of 1901, the rate is reduced to 11.9. As usual, the male deaths exceeded the female; the numbers were: Males, 246,670; females, 239,559, so that the ratio of deaths was 1,029 males to 1,000 females. As, however, there is a large excess of females over males in our population, this ratio does not give a true idea of the proportion of male to female deaths in terms of equal numbers. The death rate for males was 13.6 per thousand living, that for females 12.0. A notable feature of the death rates (standardized) is that for ages 0–5 and 5–10 years the rates are the lowest ever recorded—that for 0–5 being 1.6 and that for 5–10 being 0.2 per thousand living at those ages below the record of the year 1921. For ages 10–15 the rate remained unchanged, but from that point onward the rates show increases over 1921, growing more pronounced at the higher ages. Indeed, the rate at ages over 85 is in excess of any since 1915. The most important cause of the rise in the death rate over that of 1921 was influenza, which claimed 21,498 victims, as against only 8,995 in the preceding year. Thus, this one disease alone was responsible for nearly half the increase in deaths recorded. Diseases of the heart caused 59,837 deaths, an increase of 6,127 over the number for 1921; bronchitis claimed 40,912 victims, as compared with 33,684 in 1921, and pneumonia 40,930, as compared with 34,708.

With an infant mortality rate of 77 per thousand births, 1922 beat all records, the lowest rate heretofore recorded being 80 in 1920. The progress made in the saving of infant life is shown by going back only to the beginning of the present century. In 1901 the rate was 151, nearly double that of 1922. How important this saving of infant life is, in view of the declining birth rate, may be appreciated from the fact that, while in 1901 the births were nearly 150,000 more than in 1922, the survivors in the latter year were only 60,000 fewer. Thus, by the improvement in our infant death rate, more than half the decline in the numbers of births has been made up. The number of deaths of infants under one year of age in 1922 was 60,121; had the infant mortality rate been equal to that of 1901, the number would have been nearly 118,000.

[1] The *Journal* of the American Medical Association.

AWARDS OF THE ELLIOT MEDAL FOR THE YEARS 1921, 1922, 1923

GRATIFYING response has been made to the request of the Elliot Medal Award Committee for nominations for the award. Titles of many interesting and valuable works have been submitted for each of the years for which the awards are to be made by the National Academy of Sciences in the spring of 1924. The committee desires again to call attention to the terms of the Deed of Gift, which are as follows:

> One such medal and diploma shall be given in each year and they, with any unexpended balance of income for the year, shall be awarded by the said National Academy of Sciences to the author of such paper, essay or other work upon some branch of zoology or palaeontology published during the year as in the opinion of the . . . judges in that regard shall be the most meritorious and worthy of honor. The medal and diploma and surplus income shall not, however, for more than two years successively, be awarded for treatises upon any one branch of either of the sciences above mentioned. . . .
>
> As science is not national the medal and diploma and surplus income may be conferred upon naturalists of any country, and as men eminent in their respective lines of scientific research will act as judges, . . . no person acting as such judge shall be deemed on that account ineligible to receive this annual gift . . . if, in the opinion of his associates, he shall, by reason of the ex-

cellence of any treatise published by him during the year, be entitled to receive them.

The committee will be glad to receive further nominations up to the close of the year 1923, which should be addressed to the secretary of the National Academy of Sciences, Smithsonian Institution, Washington, D. C.

THE COMMITTEE ON PACIFIC INVESTIGATIONS OF THE NATIONAL RESEARCH COUNCIL

FOR some years the Division of Foreign Relations of the National Research Council has maintained a committee on Pacific investigations. The purposes of this committee have been to encourage research undertakings in the Pacific area, especially of problems which are peculiar to that region. The committee has also represented American scientific interests in two Pan-Pacific Science Congresses which have been held, one at Honolulu in 1920 and the second this last summer in Australia.

The committee represents the continuation of a movement which was begun a number of years ago, making for concerted study of the scientific problems of the Pacific area, regarding that area as a distinct regional unit. This movement dates back to the organization of a committee in the National Academy of Sciences to direct attention to the importance of developing scientific work in the countries within and bordering upon the Pacific Ocean, both for the welfare of that region itself and also on account of the important contributions to scientific knowledge which would come from such studies. The early formation of the committee reflected interest in these problems which had been taken by scientific men of the Pacific Coast and by others who had had an opportunity to work upon materials from the Pacific region.

The Committee of the Research Council has recently been enlarged and now consists of the following members: *Chairman,* Herbert E. Gregory; *vice-chairman,* T. Wayland Vaughan; William Bowie, Barton W. Evermann, Elmer D. Merrill, John C. Merriam, W. E. Ritter, Leonhard Stejneger, Walter T. Swingle, Clark Wissler.

THE ROLLIN D. SALISBURY MEMORIAL FUND

THE University of Chicago announces that a committee, consisting of Thomas E. Donnelley, chairman, from the board of trustees; Professor H. H. Barrows, chairman of the department of geography; Professor E. S. Bastin, chairman of the department of geology, and two other persons not members of the board of trustees or of the university faculties, has been appointed to raise a fund of $100,000 to $150,000 to be known as the Rollin D. Salisbury Memorial Fund for the Promotion of Research in the Fields of Geology and Geography.

The income from the fund is to be used for the following specific classes of projects: (a) Field research expeditions; (b) office and laboratory researches; (c) research fellowship grants to graduate students of special promise for the conduct of specific researches; (d) aid in the publication of research results when such publication can not be otherwise arranged; and (e) other projects that come appropriately under the caption of promotion of research.

Professor Salisbury, who for over twenty years was dean of the Ogden Graduate School of Science, head of the department of geography for sixteen years, and head of the department of geology at the time of his death in 1922, left a bequest to the university of a large fund for the endowment of scientific fellowships. Dean Salisbury's influence was widely extended through graduates in geology and geography who have gone to important positions in many educational institutions.

SCIENTIFIC NOTES AND NEWS

THE REVEREND THOMAS GEORGE BONNEY, the distinguished English geologist, died at Cambridge on December 9, aged ninety years.

THE Perkin Medal, awarded annually to a chemist, residing in the United States, for the most valuable achievement in applied chemistry, has this year been awarded to Dr. Fred. M. Becket, distinguished for his work in metallurgy. The presentation will take place at the January 11 meeting of the American Section of the Society of Chemical Industry, Chemists' Club, New York City.

DR. EMIL G. BECK, Chicago, has been awarded its medal by the Radiological Society of North America for his work on radiology.

DR. F. GOWLAND HOPKINS, F.R.S., distinguished for his work on vitamins, has been presented with the gold medal of the Royal Society of Medicine, London.

THE jubilee prize of the Swedish Medical Association has been awarded Dr. R. Fahræus for his report on the speed of sedimentation of erythrocytes, entitled "The suspension stability of the blood." The Lennmalm prize is to be awarded to Dr. Sven Ingvar for his series of works on the cerebellum.

PROFESSOR CARLOS CHAGAS, director of the Institut Osvaldo Cruz in Rio de Janeiro, has been appointed foreign correspondent of the Belgian Royal Academy of Medicine.

THE resignation of Dr. Henry Frank Moore as

deputy commissioner of fisheries became effective October 31, terminating a distinguished service of twenty-seven years with the Bureau of Fisheries. Dr. Moore is succeeded by Lewis Radcliffe, a member of the bureau from 1907 until 1922, when he resigned as assistant in charge of the division of fishery industries to accept a position with the Tariff Commission.

DR. BELA SCHICK, author of the Schick test, has accepted an appointment as head of the children's service division of Mount Sinai Hospital, New York City.

M. JEAN BOSLER has been appointed director of the Marseilles Observatory.

AT a meeting of the International Committee on Marine Fisheries Investigations, Dr. H. B. Bigelow was elected permanent chairman, to succeed Dr. H. Frank Moore, resigned.

DR. ANDREW BALFOUR, retiring director of the Wellcome Bureau of Scientific Research, has been appointed the first director of the School of Hygiene, London, toward the building and equipment of which two million dollars was contributed by the Rockefeller Foundation. Dr. Balfour, before taking up his duties as director of the School of Hygiene, will carry out a mission he has already undertaken to Bermuda.

DR. H. A. GLEASON, of the New York Botanical Garden, has resigned his position as assistant director to become curator, without reduction of salary, in the same institution, and will henceforth devote his time chiefly to the investigation of the flora of northern South America. Dr. Marshall A. Howe, for many years curator, becomes assistant director.

DR. J. F. GUDERNATSCH, for twelve years a member of the faculty of Cornell University Medical College, has joined the scientific staff of the Hoffman-La Roche Chemical Works.

DR. DONALD K. TRESSLER, who has been working on the determination of iodine in sea foods for the past few months, has resigned from the service of the Bureau of Fisheries to accept an industrial fellowship in the Mellon Institute of Industrial Research of the University of Pittsburgh. He will carry out researches on chemical problems of the beet-sugar industry.

DR. ASA C. CHANDLER has resigned from the Rice Institute, Houston, Texas, to accept a position as head of the department of helminthology in the School of Tropical Medicine at Calcutta, where he will devote most of his time to research on the hookworm disease. Dr. Chandler will sail for India early in January.

DRS. T. WAYLAND VAUGHAN and A. H. Brooks, who represented the Geological Survey at the Pan-Pacific Scientific Congress in Australia, have returned to Washington.

PAUL C. STANDLEY, of the National Museum, left recently for Panama, where he is to continue the investigation of the flora of the Canal Zone, a work commenced several years ago.

THE Swarthmore College chapter of Sigma Xi held its opening meeting for the current year on November 27 in the Sproul Observatory. The results of the observatory eclipse expedition to Mexico last summer were presented by three members of the party. Director John A. Miller spoke on the observations taken for testing the Einstein theory, Dr. Ross W. Marriott discussed the corona photographs with the sixty-five foot camera, and Dr. W. R. Wright reported the spectroscopic program of the expedition.

DR. LOUIS A. BAUER gave an illustrated lecture "On the origin of the earth's magnetic and electric fields" before the departments of physics, electricity and geology of the Brooklyn Institute of Arts and Sciences on November 24. At Boston, on December 8, he gave an illustrated lecture entitled "The earth and sun as great magnets" before the Eastern Association of Physics Teachers.

AMONG the lectures announced for January, at the Carnegie Institute of Technology, are a series by Professor Harry N. Holmes, of Oberlin College, who will discuss "Colloid Chemistry," "Emulsions" and "Gels" on January 9, 10 and 11; and a series by Professor Alfred Stansfield, of McGill University, between January 14 and 19 on "The Electric Furnace for Iron and Steel."

PROFESSORS GEORGE D. BIRKHOFF, of Harvard University, and Raymond C. Archibald, of Brown University, will lecture on mathematics at the University of California during the summer of 1924.

ON November 17, Dr. Arthur L. Day, director of the Geophysical Laboratory, Washington, D. C., delivered an address at Toronto to The Royal Canadian Institute on the subject "Earthquakes and volcanic eruptions."

AT a meeting called by the Maryland Cancer Committee in Baltimore on November 18, methods for disseminating information concerning cancer were discussed. The speakers included: Dr. William H. Welch, director of the School of Hygiene and Public Health, of the Johns Hopkins University; Dr. C. Hampson Jones, health commissioner of Baltimore; Surgeon-General Hugh S. Cumming, U. S. Public Health Service; Dr. Joseph C. Bloodgood, Baltimore, and Dr. George A. Soper, new managing director of the American Society for the Control of Cancer.

THE Canadian Medical Association has arranged for a Lister oration to be given once every three years. The first oration will be given at the annual meeting of the Association at Ottawa in 1924 by Dr. John Stewart, of Halifax, who is a former house-surgeon of Lister's.

THE Royal Institution has received from Mr. Robert Mond a gift of busts and medallions of Dr. Ludwig Mond, Cannizzaro, Liebig, Berzelius, and others, and many portraits and photographs.

AT a recent meeting of the senate of the University of London, it was resolved that the physiological laboratory library should be kept together as part of the university library and be developed in connection therewith as a memorial to the late Professor A. D. Waller.

THE Clare Vaughan Infirmary at the Detroit Tuberculosis Sanatorium, Northville, was dedicated November 15 to the memory of Dr. Victor Clarence Vaughan, Jr., who died in service in France, June 4, 1919. Dr. Vaughan was the son of Professor Victor C. Vaughan, of the University of Michigan.

NEAR the new home of the New York Academy of Medicine on Sixtieth Street an eleven story office building for the exclusive use of the medical profession will be erected at a cost of $850,000.

THE American Public Health Association has announced that at its fifty-second annual meeting at Boston in October, two new sections were established. They are a Section on Health Education and Publicity and a Section on Public Health Nursing. The divisions in the association now are as follows: Public Health Administration, Laboratory, Vital Statistics, Food and Drugs, Sanitary Engineering, Industrial Hygiene, Child Hygiene, Health Education and Publicity, and Public Health Nursing.

THE *Journal* of the American Medical Association says that the national committees on international cooperation in intellectual work, which have now been appointed in seventeen countries of Europe, were invited to send delegates to the meeting of the International Committee on Intellectual Cooperation, organized by the League of Nations, which was held at Paris on November 28. These national committees will serve as correspondents and collaborators to the international committee in encouraging and facilitating intellectual cooperation among the nations. Since the last meeting of the League of Nations, national committees have been created or are in process of formation in Belgium, France, Latvia, Norway, the Netherlands and Switzerland. Similar committees were already in existence in Austria, Bulgaria, Esthonia, Finland, Greece, Hungary, Lithuania, Poland, Roumania, Czechoslovakia, and in the kingdom of the Serbs, Croatians and Slovenians.

EARLY in January Dr. Thomas Barbour, of the Museum of Comparative Zoology, accompanied by Dr. Edward Wigglesworth and Mr. W. S. Brooks, both of the Boston Museum of Natural History, will go to Cuba and Central America for an extended visit. The principal object of the trip is to start work on the organization of the biological station to be erected on Barro Colorado Island in Gatun Lake. This island is a beautiful area of virgin, tropical rain forest about six square miles in extent. Chiefly through the influence of Drs. Wheeler, Piper, Strong and Mr. James Zetek, of Ancon, Governor Morrow set aside the island, in perpetuity, as a forest reservation to be used in connection with a biological station. This station is to be managed by the executive committee of the Institute for Research in Tropical America, an organization initiated by the National Research Council. The institute is supported by the museums and colleges of America which are each asked to give a small annual grant towards maintenance. The initial funds to start building operations on the island are now being raised by the executive committee. Dr. Barbour hopes before he leaves Panama to have trails cut through the island jungle, to have a safe water supply established and some sort of living quarters erected so that the large number of naturalists who have expressed their desire to visit the island during the coming summer vacation will find reasonable accommodations for their work.

UNIVERSITY AND EDUCATIONAL NOTES

MRS. ALFRED H. ANDERSON, widow of a pioneer lumberman of Seattle, has presented to the board of regents of the University of Washington $250,000 to be expended for a building to be called the "Alfred H. Anderson Hall of the College of Forestry," in memory of her husband. The building will be constructed at once near the present Forest Products Laboratory.

THE Harvard School of Public Health formally opened its school building on Van Dyke Street, Boston, on November 21. The building which was formerly the Boston Infants' Hospital was purchased by the School of Public Health and entirely renovated.

WORK will start in the spring on the McKinley Hospital on the campus of the University of Illinois, Champaign. This $150,000 building, a gift of Senator William B. McKinley, will be one of a group which will form the south quadrangle. It will be three stories high and have a capacity of sixty beds.

THE University of California College of Dentistry has established a Lecture Foundation on Preventive Dentistry, the initial endowment being $10,000. The intention of the foundation is to present the most

recent knowledge relating to the prevention of diseases of the mouth and teeth. The prevalence and seriousness of these insidious disorders are widely recognized but not fully understood, and the faculty and alumni hold that the duty of preventing disease and promoting public health is fully as important as the relief and reparative treatment so universally needed. Dr. Arthur D. Black, dean of the Northwestern University Dental School, has been invited to give the first series of lectures. It is proposed to give the series in San Francisco and Los Angeles.

DR. MELVIN A. MARTIN, A.B. (Richmond), A.M. (Chicago), Ph.D. (Columbia), has become professor of psychology in Newcomb College, Tulane University, succeeding Dr. J. M. Fletcher.

ADDITIONS to the faculty of medicine at Dalhousie University, Halifax, N. S., as reported to the *Journal* of the American Medical Association are as follows: Clyde Holland and Margaret Chase have been appointed to full-time positions in the departments of anatomy and pathology, respectively; R. J. Bean, formerly on the staff of Western Reserve University, has been appointed associate professor of histology and embryology; Professor E. Gordon Young, associate professor of biochemistry at Western Ontario University, has been made head of the department of biochemistry; Professor J. N. Gowanloch has been appointed to succeed Professor J. A. Dawson in the department of biology. The recent affiliation of King's and Dalhousie has combined the teaching force of the two universities and Professor N. J. Symons, of King's, will become instructor in psychology to the medical classes, while Professor A. S. Walker, also of King's foundation, will lecture to the first year medical students on the "History of thought," a new subject.

DISCUSSION AND CORRESPONDENCE

THE JAPANESE EARTHQUAKE[1]

I AM writing to thank you for your kind letter of September 21 last and your card of the twenty-fifth expressing sympathy for the catastrophe that has befallen this country. I have the good fortune to assure you that I am perfectly right myself and that none of the Japanese parasitologists have been affected by the misfortune, except Dr. Miyajima, whose house was burnt down. The zoological building of this university, which is of brick, cracked badly and part of it is being taken down, but no serious damage has been done to its contents, and the personnel are all safe. The central library and the buildings used by the faculties of law, economics and letters, as well as those of physiological chemistry and pharmacology, have been lost by fire, which originated in the laboratory of physiological chemistry immediately after the earthquake. Very little of their contents have been saved, owing to the general disorder that ensued and the lack of the necessary water, although those who were at the spot fought bravely. The central library, which contained many works never to be obtained again, and in which were deposited several memorial collections, including the working library of the Sanscrit scholar Max Mueller, is a great loss for the university, and it will take years to have a similar one again.

At the time of the earthquake I was staying with my wife and family at a country place about fifty miles north of Tokyo, where the shock was bad enough, but not so bad as to damage the little house I was living in nor any in the neighborhood. People there told me they did not remember a similar shock for the past forty years. Towards the evening of that day, September 1, I could see at a far distance reflections of what I thought to be flame, and the same reflections were seen somewhat altered the next day, but I had no idea of what was going on in Tokyo. Then came the news that all Tokyo was in flame, that martial law was proclaimed, that nobody could get into the city owing to the disorder that prevailed there, etc., etc., and there was no means to send or receive information. The dreadful suspense we were compelled to be in was trying in the extreme. I, however, managed to get back to Tokyo with my family on the 6th, and to our great relief we found our own house and those we left in it all safe. My time has since been taken up entirely by meetings and conferences of various sorts in connection with the work of reconstruction for the university. Half of Tokyo is now a city of barracks and sheds, and the government have decided to build only temporary structures for themselves for ten years hence. I am, however, hoping to see Tokyo a better city than it used to be after some years.

The center of this destructive earthquake was in Sagami Sea, the home of so many interesting forms of life, and comes very close to filling a gap in the series of similar centers in the past, which form what has been called the "outer earthquake zone" of Japan, as you will see from the enclosed chart prepared before the late disaster. You may perhaps wonder why we do not abandon a country so often visited by earthquakes, but I think familiarity breeds contempt in this case, too. We are, however, taking lessons from our bitter experience and going to set up stronger structures for the university in the future.

I appreciate your kind consideration in connection with Mr. Morishita's paper. He has lately been in-

[1] Letter to Professor Henry B. Ward, University of Illinois.

ited by the Formosan Government to serve as para-itologist, but will stay in Tokyo till next year.

With best thanks for your sympathy, I am

Yours very truly,

SEITARO GOTO

IMPERIAL UNIVERSITY,
TOKYO, JAPAN, OCTOBER 30, 1923

EXTRACT FROM A LETTER TO DR. DAVID STARR JORDAN

No doubt you have had details from the press, but n case it may be of interest to see how quickly the American ships got started for relief we might men-ion that, of the two divisions (each six ships; squad-on leader making 13 in all) of Destroyers, that known as the "38th" reached here from Dairen, Chin-wangtao, etc., on the fifth to seventh, and Division No. 45, from Tsingtao got here about the eighth or ninth. The transport Merritt, from Manila, delayed by a typhoon, got here on the fifteenth, and the Meigs on the seventeenth—with large quantities of food, blankets and hospital supplies, etc. The destroyers practically stripped themselves of their own stores besides what extras they had been able to bring.

The Japanese have been greatly moved by the swift and open-handed policy of America and other na-tions; this has meant much for the morale of the nation as well as for their physical relief.

There are nearly 55,000 people still living in bar-racks in the chief centers for these temporary struc-tures in Tokyo—parks, palace and temple grounds and the like, from recent official statistics. Problems of clothing, housing and employment are most diffi-cult at present. There are over 6,000 in the little barrack village—long rows of frame (one-room divi-sions)—right in Hibiya Park here. You would be surprised to see the cheerful aspect of their neat little "streets"—the one where they have opened most of their shops having strings of gay lanterns sus-pended overhead across the street at close intervals.

We hope that the little quakes that have occurred since September 1 have not been exaggerated in the press abroad. They have not amounted to anything, being just the minor adjustments to be expected after the main shock, except perhaps for yesterday's which is said to have been independent, but not at all serious.

When we consider the courage and hard work to be seen here on every hand, and the history of San Francisco after 1906, we are sure that it will not be long before that history will be repeated here. Even now no one who may have been planning to come here need change plans.

T. INAMURU

TOKYO, NOVEMBER 6, 1923

The Imperial University of Tokyo lost its entire library, which, as I understand, though encased in a fire-proof building, had its roof lifted by an explosion in a neighboring medical school. There were between 500,000 and 700,000 volumes, many of them of ancient Japanese literature and irreplaceable.

Professor Kenzo Takahashi is now visiting the universities of America and Europe with a view to securing donations for this library. It is to be hoped that all our universities and scientific societies will respond to this appeal. Any person or institution which may wish to send one or more volumes may do so either through Professor Takahashi, or by sending them directly to Mr. T. Komatsu, director of the Toyo Kisen Kaisha, Market St., San Francisco, who will forward them without charge to Japan.

DAVID STARR JORDAN

STANFORD UNIVERSITY

THE SELECTION OF SUBJECTS FOR RESEARCH

IN the August 10 issue of SCIENCE, Dr. Eugene C. Bingham gives a discussion of this subject, with particular reference to subjects for the university. I should like to add a few words with reference to a selection for the younger students.

After stating the importance of having research problems of some value, "If the result will not be worth publication, the work is not worth attempting," he goes on to make the point that "the particular problem is of little moment to the student." For "one tiny problem quickly branches out into more fields than any one mind can compass." It is a little difficult to see how Dr. Bingham introduced philology into the study of the flow of matter, but that merely shows that Dr. Bingham has the imagination to see the connection. Another might fall down in a similar research problem, because he could not see it.

The young student can not ordinarily see such a connection, and it may be for this reason that it has come to be common practice to give them the multitude of varied courses, instead of starting them learning research. But I think the cause is more in the subjects selected. The professor is mostly interested in the fields that have been extensively studied. He wants to carry research one step further in the well-trodden road, in such directions as radioactivity, or isotopes, to mention two examples from Mr. Bingham's article. To go ahead with such subjects it is necessary first to learn the work of other leading men. Students in our colleges find it impossible to get ready to accomplish anything in such a line before graduation.

Turning to the industrial field, we find many lines which have never received the attention of a single intellect of the highest grade. There are plenty of real problems with results that would be worth pub-

lishing. Furthermore, many of these problems could be handled with but little equipment and at small expense. Why not start the student on such problems and give him a chance at learning research methods before graduation?

To be sure, such problems do not extend our knowledge of scientific laws, and so it might not be proper to call it scientific research. Instead, they are a study in finding what laws apply to particular cases in which we are interested. It is technical research rather than scientific. But it is just as truly research and uses the same methods, but the subject-matter is more in line with the age of the student.

To try to put such problems into the college course does not seem practical. One difficulty is the difference in the ability of the student and the professor to handle the problem. The professor would want the results and would see that they were obtained promptly, in this way reducing the research practically to the position of present-day laboratory experiments.

I would, therefore, suggest that the student go into the industry for his first experience at research, to some place where the results of his work would be appreciated from a financial as well as from an educational standpoint, and where he can obtain results on his own initiative that are worth publishing. As he sees the need for more general courses in various subjects, he can take these up with more interest than would be possible without his research practice.

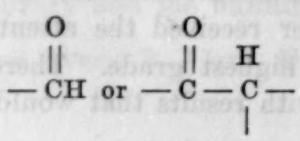
Several advertisements have appeared recently in SCIENCE for a boy to do exactly this, but so far not a single reply has been received, not even a request for further particulars. What can be the reason? Do all parents feel that the college is the only place to study research? Or possibly they do not want their sons to go into research work? Do they feel that no business firm would take on a young boy for such purposes, and so there must be some hidden deceit about the advertisement? Is the fact that the boy receives pay instead of having to pay for it the obstacle? Or what is the reason that not a single person has been sufficiently interested to inquire about it?

A. W. FORBES

WORCESTER, MASS.

REACTIONS OF CARBON DISULFIDE WITH ALDEHYDES

IN the presence of metallic sodium, carbon disulfide condenses with bodies containing "active" hydrogen to give unstable dithio acids. The reaction has been applied to compounds which contain the group



(aldehydes, ketones, esters, salts of organic acids) and is probably general for all substances capable of aldol condensation.

Aldehydes yield α-keto dithio acids, with ketones ethers of dithio acids are produced; ethyl formate reacts irregularly, giving sulfo-methane dicarboxylic acid. The new dithio acids have only been studied through their salts, etc.; the free acids are very unstable and have so far not been isolated.

Further work will extend the study of this reaction to other types of substances which undergo aldol condensation, and will report the preparation of the esters of the new dithio acids, which appear to be stable.

E. WERTHEIM

UNIVERSITY OF ARKANSAS

SCIENTIFIC AND INDUSTRIAL RESEARCH[1]

THE Report of the Committee of the Privy Council for Scientific and Industrial Research for 1922-23 shows the far-reaching importance of the work carried on under the auspices of this committee. The civil departments concerned in public administration, it is noted, are making larger use of the machinery now existing for the scientific attack upon problems that affect them. As part of the policy of coordination, periodic conferences have been held between representatives of the Department of Scientific and Industrial Research, the Development Commission and the Medical Research Council, at which the biological secretary of the Royal Society has been present. These conferences, the report states, have provided valuable opportunities for the consideration of such matters as the responsibility for the conduct of investigations at borderlines, the possibility of cooperative action in the conduct of investigations in which more than one of these departments may be interested, and the continuance of research work which has developed in such a way as to bring it outside the scope of the fund originally aiding it. These discussions have helped to define the common problems of human and animal disease, and have emphasized the interdependence of biological and physical research. They have driven home to the committee the conviction that a national policy in research, complex though it might be and directed by diverse and suitably designed organs, must be conceived and implemented as a unity. A series of conferences were held during the year with the management of the British Empire Exhibition, and a departmental committee was appointed to consider how science and the application of science to industries could best be represented. It was agreed with the exhibition authorities that they should ap-

[1] *The British Medical Journal.*

point a small committee, nominated by the Royal Society, to assume responsibility for the organization of the central scientific exhibit, and a larger committee, acting on behalf of the research associations, to deal with the general organization of sectional scientific exhibits. With regard to the plea that was made in last year's report that a vigorous search for new knowledge and the more effective application of science to industrial processes offered a potent means of reestablishing our country and maintaining its population, it is recorded with satisfaction that in December, 1922, an act with a similar end in view was passed in France, creating a national office for scientific and industrial researches and invention in connection with the Ministry of Public Instruction. The report includes a summary of the work of the various research boards and committees of the Department of Scientific and Industrial Research. At the National Physical Laboratory, in addition to the researches which it necessarily undertakes in the discharge of its primary functions as the custodian of national standards, with a view to the improvement of measurements of all kinds, including those relating to standards of quality, much research work of a general character is carried out. It includes researches involving continuous observations over a very extended period of time, and researches requiring the use of exceptionally expensive equipment or other special facilities—for example, work at very high voltages or at very low temperatures. The Food Investigation Board dealt with varied problems affecting fruit, meat, fish and eggs; many of these have been noted in our columns. Among new investigations which are being carried on are the design of a commercial gas store for fruit, the growth and respiration of fungi under various conditions, the study of vegetables in transit from producer to market, the autolysis of meat and of fish, the bacteriology of fish and the freezing point of eggs in relation to the risk of overcooling. A report from the Oxygen Committee, shortly to be published, contains descriptions of the improvement of the known method of handling liquid oxygen and liquid air on a practical commercial scale; of these methods the committe has been principally concerned with the development of the double-walled vacuum vessel as a container. Among the other boards and committees carrying on different branches of research work are the Fuel Research Board, the Geological Survey Board, the Radio Research Board, the Physics, Chemistry, and Engineering Coordinating Research Boards, the Fabrics Coordinating Research Committee, the Adhesives Research Committee and the Lubrication Research Committee. During the academic year 1922–23 the committee made 403 grants to research workers and students in training; of these 252 were allowances to students to enable them to take advantage of the facilities offered by various universities and colleges or other research institutions, 38 were personal grants to research workers to undertake independent research or to act as scientific assistants to other investigators, and 14 were grants to scientific workers to enable them to employ laboratory assistants or to purchase equipment; the total expenditure on these grants was £50,000. The total expenditure of the committee during the financial year was £497,549, of which £264,493 came directly from the Exchequer, while £89,608 represents fees for tests and special investigations for outside bodies, and repayments from the service departments.

SPECIAL ARTICLES

GELS AND THEORY OF ADSORPTION*

THIS paper is not to give a summary of the theories that have appeared on adsorption. Time nor patience would permit such a presentation. On the contrary, the speaker, with due consideration for all theories thus far advanced, is going to present a point of view which is in harmony with the experimental facts which have been found out at the University of Maryland during the past three years.

Before beginning our work, I felt that the hypothesis, which said that the electrical charge on the colloid was due to the adsorbed ion, was the most general. You all know that this point of view arose from Hardy's work, but was first clearly presented by Bredig. Helmholtz's double layer theory was another way of accounting for the electrical charge. Furthermore, you are all familiar with Freundlich's assumption of adsorbed ions and Michael's idea of surface molecules being dissociated.

After reviewing the great amount of work on adsorption, it seemed to me that we did not need more theories on adsorption until more fundamental work was done, in order to prove the falsity or truth of the theories already in print.

Our work was started on silica gel and you all know that this gel is negative with respect to water. We assumed that this negative charge was due to the Helmholtz double layer and, according to Hardy's work, we had reason to believe that if the hydrogen ion concentration was decreased, the negative charge on the gel would increase, and similarly, if you increase the hydrogen ion concentration the gel would assume a less negative charge until it would assume a positive charge when the pH had fallen below 7. The Helmholtz theory also assumes that a charge of a particular sign can not exist without one of oppo-

* Read before the Chemistry Section of the American Association for the Advancement of Science at the Boston Meeting on December 28, 1922.

site sign in its proximity; *i.e.*, when the silica gel becomes more and more negative by increasing the pH value of the solution, it should attract more and more positive ions into its proximity. With these points in mind, it seemed reasonable to suppose that a positive ion, such as would be furnished by some salt like potassium acid phosphate, would be more and more attracted into the neighborhood of the gel as the hydrogen ion became less; or, putting it in other words, that the adsorption of the potassium ion would increase with an increase in pH values. Results as shown in the following table seemed to bear out the supposition:

TABLE I

pH Value	mgm. K Ads. per gm. gel.	mgm. PO_4 Ads. per gm. gel.
9.501	9.63	—4.15
7.692	6.56	—4.15
6.086	1.74	—3.15
3.888	—0.68	—1.36

This would seem quite in tune with some of Dr. Loeb's work as far as the potassium ion is concerned, and the phosphate radical also has a tendency in the right direction, although at no time did it become positively adsorbed. Many salts of potassium and calcium were run, and there was no exception to the rule as far as the cation was concerned, but the anion presented some irregularities.

It next became of interest to find if the charge on the gel changed at a pH value of 7. Such determinations were easily run by an apparatus similar to that used by Briggs in his electroendosmosis work. Table II gives a sample of the results.

TABLE II

pH	Charge on Gel.	Time to flow 10 cm.	E.M.F.
6.526	neg.	16 min. 19 sec.	116
4.717	neg.	31 min. 54 sec.	120
3.567	neg.	32 min. 19 sec.	120
1.217	pos.	72 min. 3 sec.	119

According to Perrin's work, you would not expect this silica diaphragm to be negative in such a high hydrogen ion concentration unless it was due to a strong adsorption of some negative ion which was more strongly adsorbed than hydrogen. But the anions had been slightly, if any, adsorbed as shown in Table I.

In view of these facts it seemed necessary to make some other assumption as to the cause of the charge on the gel. The next most plausible theory seemed to be the ionization of surface molecules, but before applying this theory, a few words about the history of the ultramicron may be in order.

Work by Bütschli and others have led us to believe that the ultramicron in the hydrosol and hydrogel are identical. In the latter case the ultramicrons are closer together. It is further necessary for us to picture the ultramicrons in a hydrogel as being held together by a certain amount of cohesion and the interstices between these ultramicrons being filled with water.

Suppose that the molecules of silicic acid at the surface of the ultramicron suffered ionization. Then the ultramicron would become negative and might be represented thus:

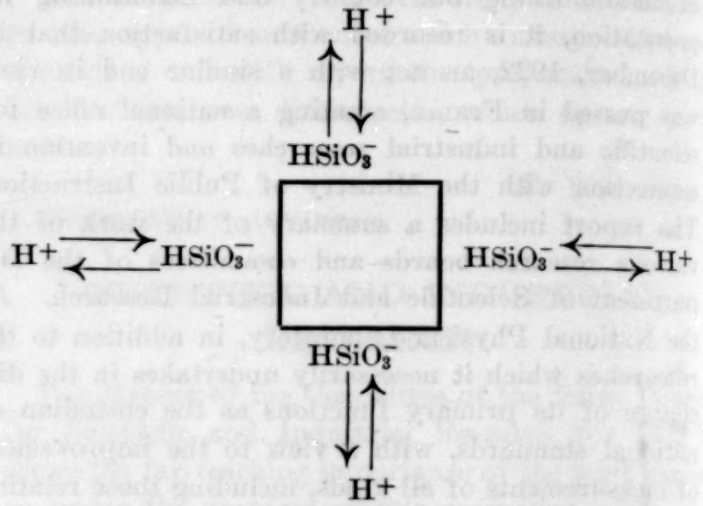


FIG. 1

The charge on the gel is now accounted for satisfactorily, and it is next to be seen if this theory will explain experimental facts.

On this theory the ultramicron should have a charge much in excess of a common ion, for, as illustrated in Figure 1, there would undoubtedly be many surface molecules ionizing. This is true to facts, for it has been shown that the charge on an ultramicron is many times that of a single ion.

Suppose an acid is added to these ultramicrons. This surface ionization will be decreased, and the gel will become less negative until it finally becomes positive, as shown in Table II. The equilibrium is expressed thus:

$$H^+ + H\text{-}SiO_3 \rightleftarrows H_2SiO_3 \rightleftarrows H\text{+}SiO_2 + O\text{-}H$$

$pH < 1.217$ $\qquad$ $pH > 1.217$

Again, suppose that some alkali is added, such as sodium hydroxide, then the regular neutralization action should take place thus:

$$\square HSiO_3^- + \boxed{H^+ + OH^-} + Na^+ \longrightarrow \square HSiO_3^- + Na^+ + H^+ + OH^-$$

i.e., sodium silicate is formed at the surface of the ultramicron. These surface molecules of silicate would be more highly ionized than the silicic acid and hence, the negative charge of the gel should increase. This is again true to experimental facts.

The sodium ions in equilibrium with the silicate ions on the surface of the ultramicron would have a tendency to diffuse through the solution, but they can

not go without taking the ultramicron in their train. This should happen when the ultramicron does not have too great mass, and in such a case we have what is known as peptization, but if the mass of the ultramicron is too great, the sodium ions are not able to pull it along and consequently the sodium ion is held in the vicinity of the ultramicron and we have what might be termed adsorption. Experimental facts bore out these assumptions, for when the silica gel was treated with a solution of sodium hydroxide until the alkalinity of the solution had entirely disappeared and the analysis run, it was found that part of the sodium was found in the solution with its attending ultramicrons, while the balance was in the proximity of the ultramicrons which had too great mass to migrate. The surface of the unmigratable ultramicrons is so great that the result was a fairly high so-called adsorption.

In the light of this, it was reasonable to suppose that the adsorption of potassium, as shown in Table I, might be due to a replacement of the sodium, but if this were the case, the total adsorption of the sodium and potassium should be equal to the adsorption of the sodium, and what part of this adsorption was potassium would depend on the ratio of the solubilities of sodium and potassium silicates. Furthermore, if some salt like silver nitrate were used which had a more insoluble silicate than the potassium more of the sodium should be replaced but the total adsorption should be the same. A few results are given in Table III to show the general run of experiments.

TABLE III

ADSORPTION OF METALS BY THE HYDROGELS OF SILICON

Solutions Used		Equivalents of Na Ads. per grm. Gel.	Equivalents of M.[1] Ads. per grm. Gel.	Total Equivalents of Metal Ads. per grm. of Gel.
C=0.02N NaOH	C=0.02N $NaNO_3$	45×10^{-5}		45×10^{-5}
NaOH	KNO_3	14×10^{-5}	31×10^{-5}	45×10^{-5}
NaOH	$AgNO_3$	12×10^{-5}	33×10^{-5}	45×10^{-5}

Using similar notation to that already used, the reactions might be represented thus:

$$\square HSiO_3Na + KNO_3 \rightleftharpoons \square HSiO_3K + NaNO_3 \quad (1)$$

$$\square HSiO_3Na + AgNO_3 \rightleftharpoons \square HSiO_3Ag + NaNO_3 \quad (2)$$

According to the results given in Table III, equation (2) would be carried nearer completion than equation (1) before equilibrium was established, but the total metal adsorbed in any case is the same.

[1] Metal other than sodium.

These are a few points to show the trend of our results and conclusions in regard to silica gel. We are now investigating alumina and ferric oxide gels in order to find what theories will best apply to these cases, but the work has not yet reached such a state that we wish to draw definite conclusions, but our present work seems to indicate that there are four different types of adsorption from solution; namely, (1) chemical adsorption, which follows the mass law, (2) exchange adsorption, where one ion is adsorbed at the expense of replacing an equivalent amount of a second ion, (3) partition ratio adsorption, where the adsorption obeys Henry's law, and (4) electronic adsorption, where the adsorbed material seems to be held by a secondary valence. There is also what might be called a fifth type which is a combination of two or more of these types. We feel quite sure that we have a combination adsorption in the case of both ferric oxide and alumina gels, but we shall wait until a later date to report more detail on this.

NEIL E. GORDON

UNIVERSITY OF MARYLAND,
CHEMISTRY DEPARTMENT

NORTH CAROLINA ACADEMY OF SCIENCE

THE twenty-second annual meeting of the North Carolina Academy of Science was held at the North Carolina College for Women at Greensboro, May 4 and 5, 1923.

The secretary reported a total membership of 203, an increase of 40 members over the preceding year, and also that some 60 members were now members of the American Association for the Advancement of Science, an increase of 50 per cent. over the previous year.

The following officers were elected for the ensuing year: *President,* C. M. Heck, Department of Physics, State College; *vice-president,* J. P. Givler, Department of Biology, North Carolina College for Women; *secretary-treasurer,* Bert Cunningham, Department of Biology, Trinity College; *executive committee*—A. Henderson, Department of Mathematics, University of North Carolina; H. B. Arbuckle, Chemistry Department, Davidson College; J. W. Nowell, Chemistry Department, Wake Forest College.

The North Carolina Physics Teachers Association, meeting with the Academy, elected officers as follows: *President,* W. T. Wright, North Carolina College for Women; *vice-president,* A. A. Dixon, State College; *secretary-treasurer,* A. L. Hook, Elon College.

The North Carolina Section of the American Chemical Society, meeting at the same time and place, elected the following officers: *President,* J. O. Halverson, Department of Agriculture; *vice-president,* F. C.